Field Report for Airborne Data Collected In Support of US EPA Region 6 Intercontinental Terminals Company LLC Fire 19 April 2019

Background

On 17 March 2019 a large fire was reported at the Intercontinental Terminals Company LLC (ITC) located in Deer Park, TX. Local reports indicate that the fire started at about 1030 local in an 80,000 barrel (capacity) tank storing naphtha. The ITC facility is located on the southern shore of the Houston ship channel in the City of Deer Park, TX. The geographical coordinates of the facility are 19.7322N, 95.1236W (figure 1).

The material reported in the fire is Naphtha. Naphtha is generally composed of either the first or second sequence of distillate obtained during primary distillation. Light naphtha is composed of light fraction straight chain and simple aromatics, typically less than 6 carbons while heavy naphtha consist of larger compounds (C6 plus) which normally is used as feed for catalytic cracking. Since the fraction of Naphtha is crude dependent, there is not a simple formula for the material.

The US EPA Region 6 requested that the ASPECT system be deployed to provide monitoring support on 17 March 2019 and ASPECT completed a 7 pass mission at 1847 local. Acetone was detected on the first 2 passes (data collection 3 and 4) which were near the fire at a concentration estimated below 1 ppm (0.154 ppm and 0.357 ppm, respectively). No other compounds were detected.

ASPECT conducted a second flight over the facility on 18 March 2019. Analysis of IR data confirmed reports that the fire had expanded to multiple tanks. Specifically, the thermal signature of the fire and resulting heated air plume was measurably larger than that observed in the first flight. Crew reports indicated that the plume rise was still active with the lofted plume occupying a region between 2000 and 6500 feet above ground with movement to the west. Spectral analysis of FTIR data indicated that compounds including 1-butene, 2-butene, isoprene, and acetone were detected primarily in a downwind portion of the plume with the highest values being just above 1 ppm.

ASPECT conducted a third flight over the ITC fire on 19 March 2019. Analysis of data indicated that the fire had grown as evident by the larger thermal signature and direct confirmation from aerial images. Plume geometry was assessed with the aircraft with findings showing the plume was about 47 miles in length, 17 miles wide at the largest extent and ranged in altitude from a floor of 1500 feet to a ceiling of 5000 feet. No chemical detections were reported on this flight.

ASPECT conducted a fourth flight over the ITC fire on 20 March 2019. Analysis of data indicated that the fire had been extinguished. Analysis of FTIR data showed detections of acetone and SO_2 to west of the farm and isobutylene and isoprene south of the farm. All concentrations were detected below 1 ppm.

Due to reports of vapors observed in the Deer Park vicinity ASPECT was requested to fly a fifth mission on 21 March 2019 near the impacted tank farm, and locations in Deer Park, La Porte, Galena Park and Jacinto City. Analysis of data showed normal temperatures within the farm and low levels of typical compounds within the urban atmosphere. Detected compounds included acetone and isobutylene at concentrations at or below 1 ppm.

ASPECT conducted a series of flight on 22 March 2019 with the focus being a possible breach of the tank farm secondary containment structure, discharge of foam and other material from the tank farm migrating into the ship channel and investigation of a re-ignition of a fire in the tank farm. IR results clearly showed the presence of material migrating into the ship channel and the presence of hot spots within the tank farm (corresponding to the fire). Detected compounds included acetone, 1, 3-butadiene, 1-butene, isobutylene and isoprene. Compounds detected in the general vacuity had concentrations less than 0.5 ppm while detections north of the tank farm during the fire showed levels less than 2 ppm.

ASPECT was dispatched on 23 March 2019 to fly a general data collection mission over the tank farm, at the confluence boom area on the ship channel and in a residential area northwest of the general area. Data continued to show that tanks in the NW corner were warmer than others in the tank farm with estimated temperatures being in the 30^{o}C to 40^{o}C range. IR images collected over the confluence into the ship channel showed boomed oil products with some leakage occurring. No chemical detections were observed on the flight.

ASPECT conducted a short flight on 24 March 2019 but was forced to return to base due to weather. Note that this aborted mission was flight 11. ASPECT conducted flight 12 on 25 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery continued to show that tanks in the NW corner were warmer than others in the tank farm. IR images collected over the confluence into the ship channel continued to show boomed oil products with some leakage occurring with sheen being driven to the southwest due to winds. No significant chemical detections were observed on this flight.

ASPECT conducted flight 12 on 26 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected on this flight indicated that the NW tanks in the tank farm were cooler than on previous flights. IR data collected over the confluence into the ship channel continued to show sheen in the waterway. No significant chemical detections were observed on this flight.

ASPECT conducted a flight 14 on 27 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected on this flight indicated that the NW tanks in the tank farm were essentially at ambient temperature. Analysis of FTIR data showed one cluster of isobutylene north of the site at maximum levels of 1.60 ppm. IR and photographic data collected over the confluence area showed a reduction in the amount of trapped product. Leakage was still present but in less amounts as on prior flights.

ASPECT conducted flight 15 on 28 March 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. The flight was impacted by isolated low level clouds. Imagery collected on this flight indicated that the NW tanks in the tank farm were at ambient temperature. IR and photographic data collected over the confluence area indicated that product was captured by the upstream boom and no significant boom leakage was present.

ASPECT conducted flight 16 on 31 March 2019. Imagery collected over the tank farms showed that six of the tanks in the farm are in the process of being removed. All structures were found to be at ambient temperature. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with some leakage observed pushed against the ship channel boom. No compound detections were observed on this mission.

ASPECT conducted flight 17 on 1 April 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected over the tank farms showed a similar state as on the prior flight, namely that six of the tanks in the farm are in the process of being removed or collapsed. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with some leakage. No compound detections were observed on the mission.

The tank farm, confluence and downwind areas were flown on the morning of 2 April 2019 as part of flight 18. Imagery collected over the tank farms showed a similar state as on the prior flights with no change in the character of the site or tanks. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with some sheen leakage in the northeast most structure. No compound detections were observed on this mission.

ASPECT conducted flight 20 on 3 April 2019 with the goal to conduct a general survey at the tank farm and downwind of the site. Imagery collected over the tank farms showed no significant change from the mission on 2 April 2019. IR and photographic data collected over the confluence area indicated that product continues to be present in the boom network with minor sheen leakage in the northeast most boom structure. No compound detections were observed on the mission.

On 8 April 2019 ASPECT conducted flight 21with the goal to conduct a general survey at the tank farm and downwind of the site. Low levels of isoprene (0.76 ppm), 1-butene (1.55 ppm) and 1, 3-butadiene (0.70 ppm) were detected upwind of the site. No

detections were observed on top or downwind of the tank farm. Imagery of the tank farm area indicated no significant change from the mission on 3 April 2019. IR and photographic data collected over the confluence area indicated that the amount of trapped product appears to be greatly reduced from the previous flight. Some material was present on the outside of the boom structure and may be channel debris. No sheen was observed in the imagery.

As with prior flights the goals for the mission conducted on 9 April 2019 included conducting a general survey at the tank farm, downwind areas and the confluence area. No detections were noted on the mission. Imagery of the tank farm area indicated no significant change from the mission on 8 April 2019. IR data did show light sheen in the channel but the source of the sheen is unclear. No evidence of sheen was observed in the visible data.

ASPECT conducted a mission on 10 April 2019 with flight goals consisting of chemical and photographic data collection over the tank farm area, downwind areas from the tank farm and the confluence area. No chemical detections were observed. Imagery (both aerial and oblique) of the tank farm area indicated no significant change from the mission on 9 April 2019. A small amount of isolated product may have been present in the channel but no boom leakage was observed. IR analysis did show the possibility of light sheen or upwelling (prop wash) thermal contrast in the channel but no direct indication of product.

ASPECT chemical data collected on the 12 April 2019 mission showed no detections. The most significant observation was the application of foam to the NE tanks within the farm. IR and visible imagery indicated the quantity of product appears to be reduced with sheen remaining in the boomed areas. A small amount of sheen leakage was observed migrating into the main channel.

The ASPECT mission conducted on 14 April 2019 showed no chemical detections. Both IR and visible analysis of the tank farm area indicated no activity (no foam). A similar analysis of the confluence area showed no indication of trapped product and only sheen in the boomed area. A small amount of sheen leakage was observed migrating into the main channel.

Analysis of chemical data collected on 15 April 2019 showed no detections. Analysis of visible and IR imagery over the tank farm exhibited no change from the mission conducted on 14 April 2019. Imagery data over the boomed area along the ship channel did not show any product or sheen present in any of the images.

Due to poor flight conditions (low ceiling) ASPECT did not conduct missions on 16, 17 or 18 April 2019. On 19 April 2019 ASPECT was dispatched to run a standard mission over the ITC facility with the goal to collect chemical and photographic data over the tank farm, confluence and downwind areas. This report summarizes the findings of the mission.

Figure 1: ITC, Deer Park, TX

ASPECT response to this Mission/Incident was in support of:
US EPA Region 6. OSC: Adam Adams

ASPECT System

The US EPA ASPECT system collects airborne infrared (IR) images and chemical screening data from a safe distance over the site (about 3,000 ft AGL). The system consists of an airborne high speed Fourier transform infrared spectrometer (FTIR) coupled with a wide-area IR line scanner (IRLS). The ASPECT IR systems have the ability to detect compounds in both the 8 to 12 micron (800 to 1200 cm-1) and 3 to 5 micron (2000 to 3200 cm-1) regions. The 8 to 12 micron region is typically known as the atmospheric window region since the band is reasonably void of water and carbon dioxide influence. Spectrally, this region is used to detect carbon - non-carbon bonded compounds. The 3 to 5 micron region is also free of water and carbon dioxide but typically does not have sufficient energy for use. This band does show use in high-energy environments such as fires. The carbon - hydrogen stretch is very common in this region.

A digital Nikon DX2 camera (12.4 mega pixel CMOS 3:5 aspect ratio, 28 mm wide-angle lens) collects visible aerial imagery as part of the core data product package. The camera timing system is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. All imagery is geo-rectified using both aircraft attitude correction (pitch, yaw, and roll) and GPS positional information. Imagery can be processed while in flight or approximately 600 frames per hour can be processed once the data are downloaded from the aircraft.

An Imperx mapping camera (29 mega pixels; mapping focal plane array) provides a similar aspect ratio and aerial coverage. Like the Nikon DX2, it is connected to the primary IR sensors and provides concurrent image collection when other sensors are triggered. These images are often digitally processed in lower resolution so they can be transmitted via satellite communication. The high resolution images (>20 MB each) are pulled from the ASPECT after the sortie and are available at a later time.

All aerial photographic images collected by the ASPECT system are ortho-rectified and geospatially validated by the reachback team. In general, this consists of conducting geo-registration using a Digital Elevation Model (DEM) which promotes superior pixel computation and lessens topographic distortion. The image is then check by a team member (using a Google Earth base map) for proper location and rotation

Data is processed using automated algorithms onboard the aircraft with preliminary results being sent using a satellite system to the ASPECT reachback team for QA/QC analysis. Upon landing preliminary data results are examined and validated by the reachback team.

Data Results Flight 27, 19 April 2019

Weather Conditions and Crew Report

Weather for the mission is given in table 1. The crew reported that winds at flight level (2800 ft) were from 300 degrees at 30 kts (15.5 m/s) with light turbulence encountered with. The crew did not report any apparent change in the site from the last flight.

Table 1. ITC Fire Mission Weather 19 April 2019

Parameter	Surface (0900)
Wind direction	320 degrees
Wind speed	1 m/s
Temperature	17.2^{o}C
Humidity	57%
Dew Point	9.4^{o}C
Pressure	1016 mb
Ceiling/Clouds	Clear to 17000 AGL

The time for lift-off was given as 0840. The aircraft was over the site at 0907 and collected a total of 5 data collection passes over the ITC site. Flight information is summarized in Appendix A and Figure 2.

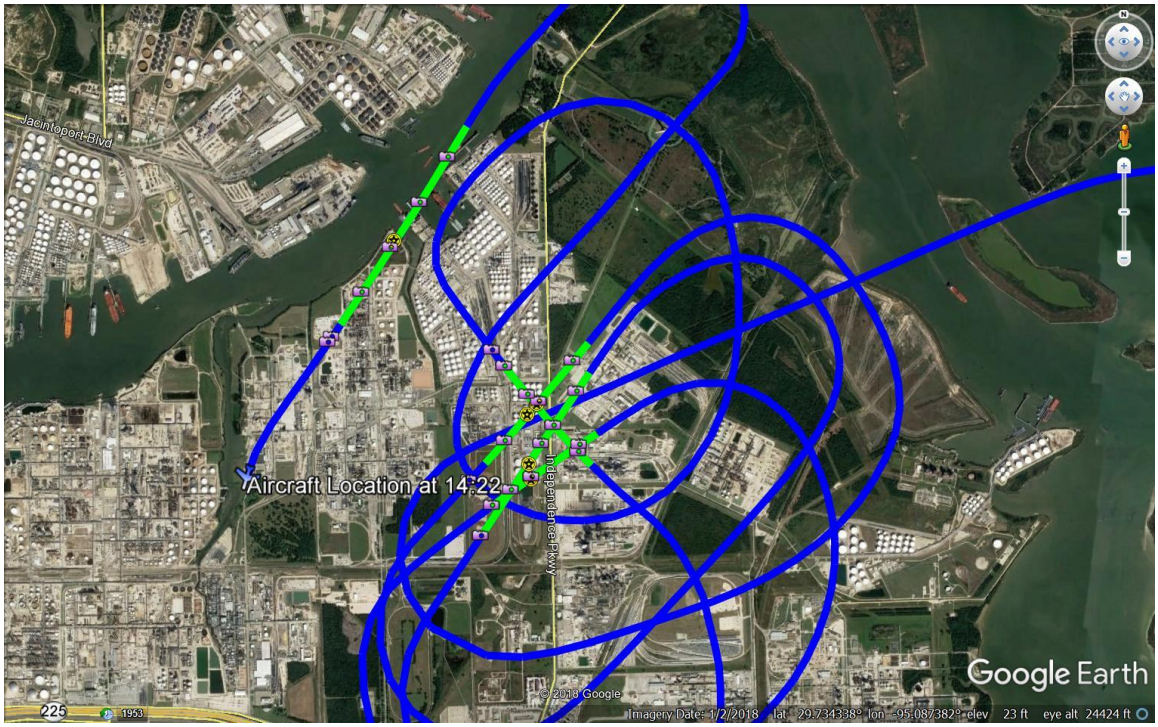

Figure 2: Flight line data for 19 April 2019, Flight 27. The blue lines represent the ASPECT flight path, green lines represent when the Infrared Line Scanner was actively collecting data, and the camera icons represent when a photo was taken.

General Data Quality Objective

The following general data quality objectives are employed in conducting emergency response data collection with ASPECT:

1. To support overall situational analysis of the incident including aerial photography and IR imagery
2. To screen the incident for the presence of selected chemicals
3. To estimate the location and concentration of plumes being generated by the incident.

Line Scanner Data Results

A total of 1 test and 5 data passes were made in the proximity of the impacted tank farm and also in extended areas surrounding the site and infrared line scanner images were generated for each pass. Figure 3 shows a typical 3-band infrared image obtained from data collected for Run 2. No apparent change in the image was observed as compared to the last flight on 15 April 2019. As with prior flights, all tanks show normal solar heating with the two tanks in the NE exhibiting cooler temperatures than the others.

The confluence area is shown in Figure 4. Change was noted while examining this image including the removal of the boom structure and the complete absence of sheen in the

channel. Light thermal signatures present in the open channel are due to prop wash from the ships.

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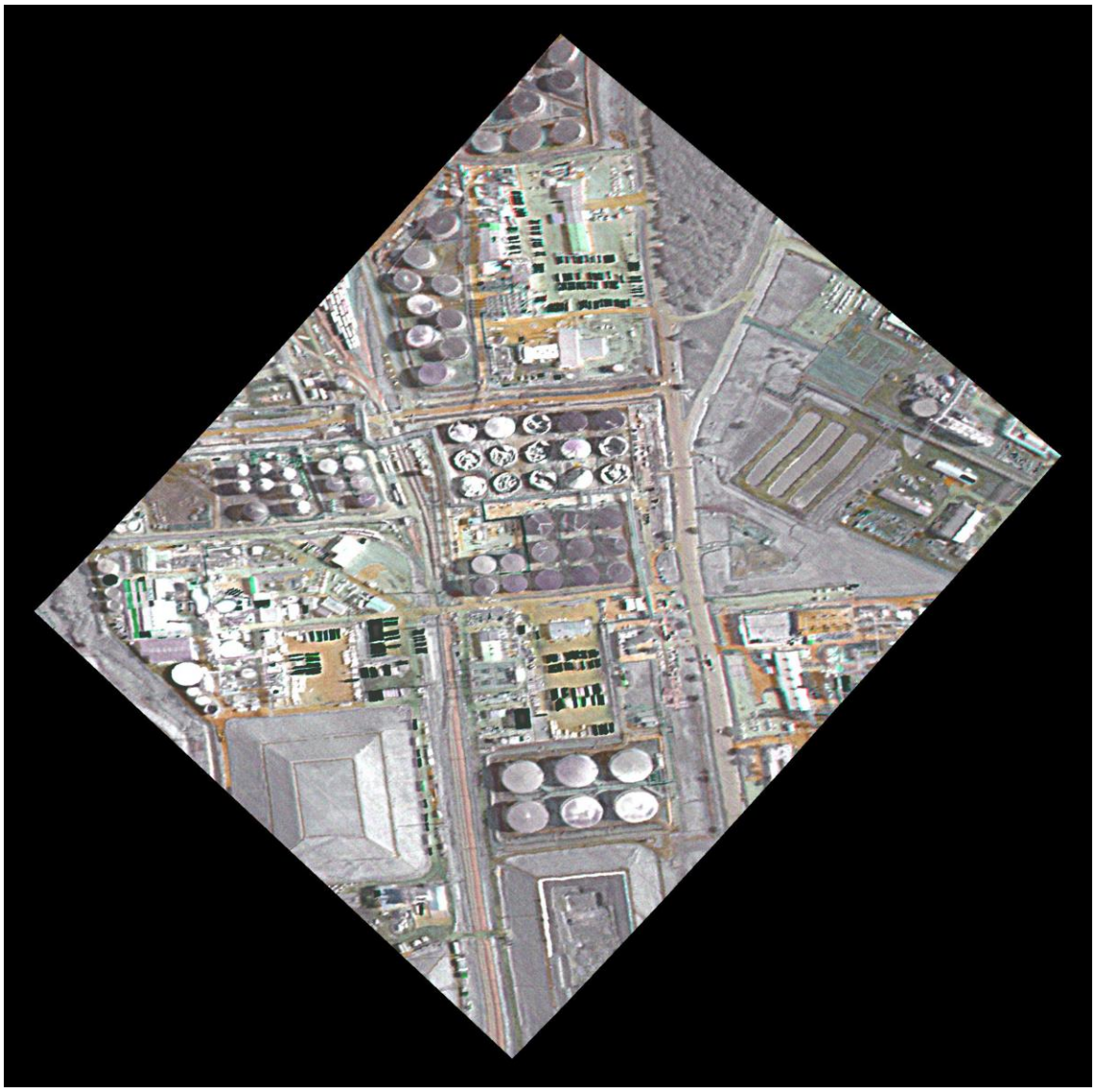

Figure 3: IR image of ITC data for 19 April 2019, Flight 27, Run 2

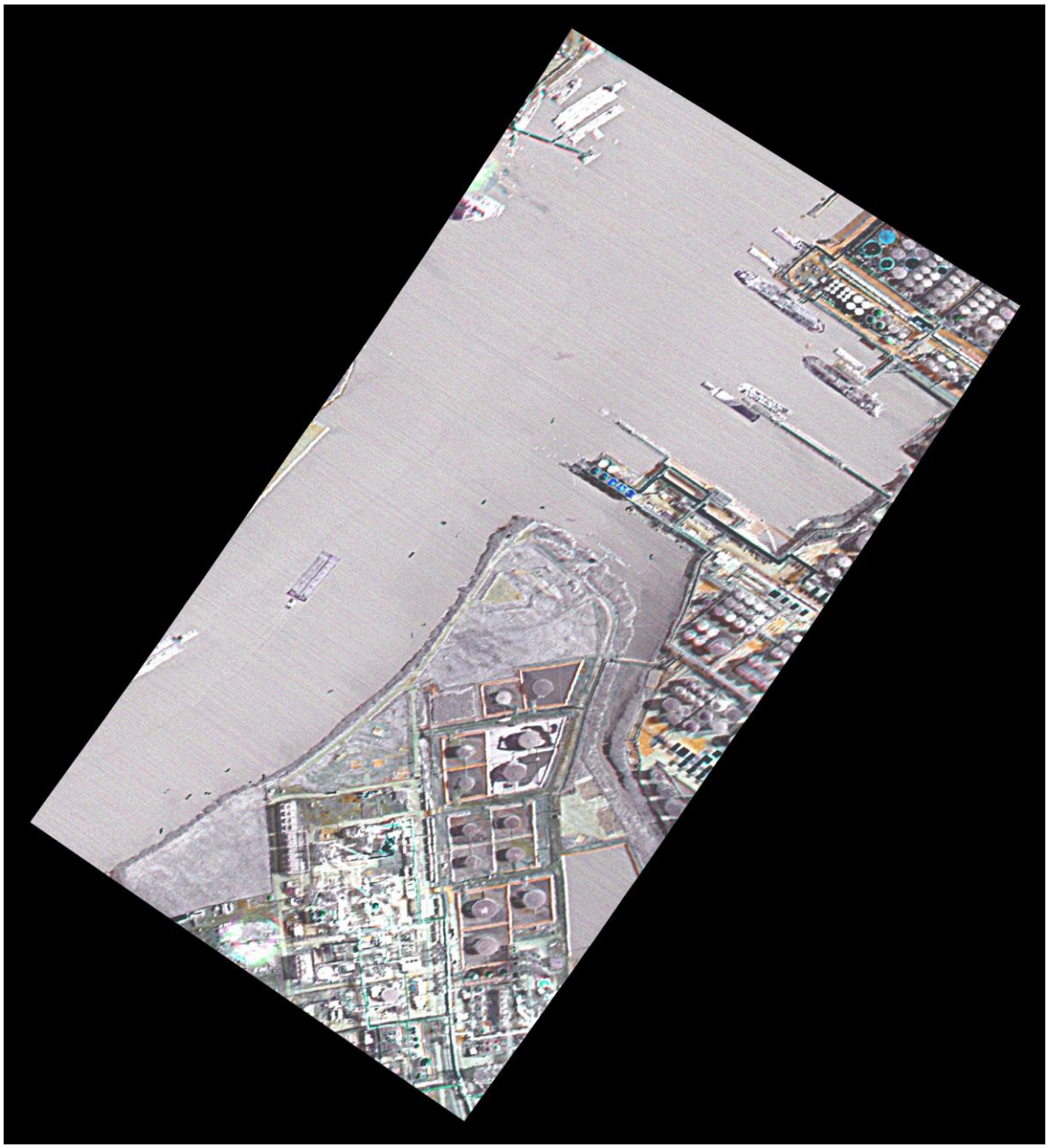

Figure 4: IR Image of Contained Oil 19 April 2019, Flight 27, Run 6

FTIR Data Results

FTIR Spectral data at a resolution of 16 wavenumbers was collected for each pass. ASPECT uses an automated detection algorithm to permit compounds to be analyzed while the aircraft is in flight. 72 compounds are included in this algorithm and the list and associated detection limits are given in Tables 2. In addition, collected data are also manually analyzed by comparing any detected spectral signatures to a collection of published library spectra.

No detections were observed during the mission. Details of the mission are given in Table 3.

TABLE 2 - Chemicals Included in the ASPECT Auto-Processing Library

Acetic Acid	Cumene	Isoprene	Propylene
Acetone	Diborane	Isopropanol	Propylene Oxide
Acrolein	1,1-Dichloroethene	Isopropyl Acetate	Silicon Tetrafluoride
Acrylonitrile	Dichloromethane	MAPP	Sulfur Dioxide
Acrylic Acid	Dichlorodifluoromethane	Methyl Acetate	Sulfur Hexafluoride
Allyl Alcohol	Difluoroethane	Methyl Ethyl Ketone	Sulfur Mustard
Ammonia	Difluoromethane	Methanol	Nitrogen Mustard
Arsine	Ethanol	Methylbromide	Phosgene
Bis-Chloroethyl Ether	Ethyl Acetate	Methylene Chloride	Phosphine
Boron Tribromide	Ethyl Formate	Methyl Methacrylate	Tetrachloroethylene
Boron Triflouride	Ethylene	MTEB	1,1,1-Trichloroethane
1,3-Butadiene	Formic Acid	Naphthalene	Trichloroethylene
1-Butene	Freon 134a	n-Butyl Acetate	Trichloromethane
2-Butene	GA (Tabun)	n-Butyl Alcohol	Triethylamine
Carbon Tetrachloride	GB (Sarin)	Nitric Acid	Triethylphosphate
Carbonyl Chloride	Germane	Nitrogen Trifluoride	Trimethylamine
Carbon Tetraflouride	Hexafluoroacetone	Phosphorus Oxychloride	Trimethyl Phosphite
Chlorodifluoromethane	Isobutylene	Propyl Acetate	Vinyl Acetate

Table 3. Chemical Results Summary, Flight 27

Run	Date	Time (UTC)	Chemical	Max Concentration ppm
1	19 April 2019	0901	Test	Test
2		0907	ND	None
3		0910	ND	None
4		0913	ND	None
5		0916	ND	None
6		0921	ND	None
ND – Non-detect				

Aerial Photography Results

A full set of high resolution aerial digital photography was collected as part of the flight. Figure 5 shows representative overhead images collected as part of each pass over the tank farm. No change from previous flights was observed in the image. A similar conclusion is reached based on the oblique imagery (Figure 6).

Figure 7 shows an overhead aerial image of the confluence area along the ship channel. As noted with the analysis of the IR image, the boom network in the area has been

removed. A few clean-up booms are present in the drainage channel and being towed by boats can be seen. No product or sheen evident in the image. An oblique image collected over the same area (Figure 8) confirms this conclusion.

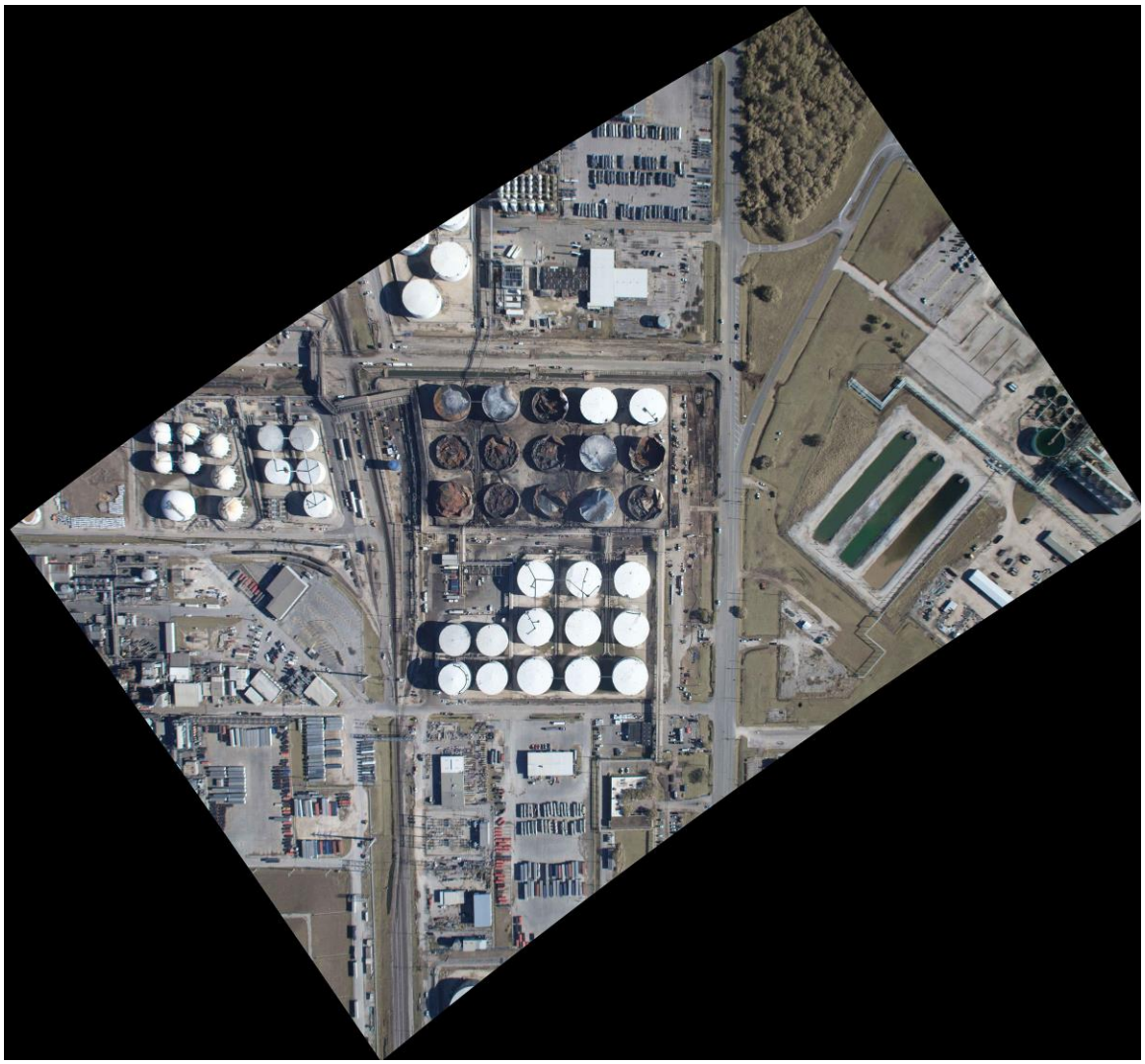

Figure 5: Aerial Image of the Tank Farm, 19 April 2019, Flight 27

Figure 6: Oblique Image of the Tank Farm (looking toward the North), 19 April 2019 Flight 27

Figure 7: Aerial Image of the Ship Channel Boom Area, 19 April 2019, Flight 27

Figure 8: Oblique Image of the Ship Channel Boom Area, 19 April 2019, Flight 27

Conclusions

ASPECT conducted a routine data collection flight over the ITC tank farm and ship channel confluence area on 19 April 2019. No chemical detections were noted. Examination of visible and IR imagery over the tank farm area showed no difference from data collected on 15 April 2019. Imagery data collected over the ship channel did show the removal of the boom network with only clean-up booms remaining. No product or sheen was observed in any of the images.

Appendix A

Abbreviations:

DEM – Digital elevation model
Alt – Altitude (in feet)
MSL – Mean sea level altitude (in feet)
Digital – Digital photography file from the Nikon D2X camera
MSIC – Digital photography file from the Imperx mapping camera
FTIR – Spectral IR data collected with a Fourier Transform Infrared Spectrometer
IRLS – Infrared Line Scanner
Jpg – JPEG image format
UTC – Universal Time Coordinated
img – Spectral data format based on Grams format

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Mission:   2019-04-19 ITC Fire

Date:      4/19/2019
Time UTC: 13:53

Aircraft Number: N9738B
Pilot: Beorn Ledger
Copilot: Todd Seale
Operator: Jimmy Crisp
Aft Operator: Steven Brister
Ground Controller: Tim Curry

DEM: Using elevation from DEM Database
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Run: 1 Time: 14:01:34 UTC
        Alt: 2878 ft MSL  Elev: 18 ft  Elevation from DEM Database
        Vel: 107 knots  Heading: 278

Digitals:  None
MSIC: 3
        20190419140140296.jpg
        20190419140146661.jpg
        20190419140153915.jpg
FTIR: 1
        20190419_140137_A.igm
IRLS: 1
        2019_04_19_14_01_39_R_01 TA=8.0;TB=28.0;Gain=3
Gamma Runs:  None

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Run: 2 Time: 14:07:14 UTC
        Alt: 2802 ft MSL Elev: 24 ft Elevation from DEM Database
        Vel: 120 knots Heading: 234

Digitals: None
MSIC: 4
        20190419140720766.jpg
        20190419140727115.jpg
        20190419140733480.jpg
        20190419140739829.jpg
FTIR: 1
        20190419_140719_A.igm
IRLS: 1
        2019_04_19_14_07_19_R_02 TA=5.9;TB=25.9;Gain=3
Gamma Runs: None

Run: 3 Time: 14:10:28 UTC
        Alt: 2765 ft MSL Elev: 25 ft Elevation from DEM Database
        Vel: 124 knots Heading: 225

Digitals: None
MSIC: 4
        20190419141034153.jpg
        20190419141041407.jpg
        20190419141047772.jpg
        20190419141054121.jpg
FTIR: 1
        20190419_141032_A.igm
IRLS: 1
        2019_04_19_14_10_33_R_03 TA=8.5;TB=28.2;Gain=3
Gamma Runs: None

Run: 4 Time: 14:13:34 UTC
        Alt: 2794 ft MSL Elev: 24 ft Elevation from DEM Database
        Vel: 113 knots Heading: 248

Digitals: None
MSIC: 3
        20190419141340277.jpg
        20190419141347531.jpg
        20190419141353895.jpg
FTIR: 1
        20190419_141338_A.igm
IRLS: 1
        2019_04_19_14_13_39_R_04 TA=9.5;TB=29.4;Gain=3
Gamma Runs: None

Run: 5 Time: 14:16:34 UTC

Alt: 2822 ft MSL Elev: 18 ft Elevation from DEM Database
Vel: 81 knots Heading: 324

Digitals: None
MSIC: 5
20190419141640044.jpg
20190419141646393.jpg
20190419141653647.jpg
20190419141700013.jpg
20190419141703636.jpg
FTIR: 1
20190419_141637_A.igm
IRLS: 1
2019_04_19_14_16_39_R_05 TA=10.0;TB=29.9;Gain=3
Gamma Runs: None

Run: 6 Time: 14:21:45 UTC
Alt: 2690 ft MSL Elev: 3 ft Elevation from DEM Database
Vel: 121 knots Heading: 225

Digitals: None
MSIC: 6
20190419142152360.jpg
20190419142158709.jpg
20190419142205059.jpg
20190419142211423.jpg
20190419142217773.jpg
20190419142218677.jpg
FTIR: 1
20190419_142149_A.igm
IRLS: 1
2019_04_19_14_21_50_R_06 TA=9.8;TB=29.8;Gain=3
Gamma Runs: None